NOTE ON THE ZODIACAL LIGHT.*

By Henry Carwill Lewis.

The results of a series of observations upon the zodiacal light made by the writer, extending over a period of nearly five years, is here recorded. The special precautions taken, both to train the eye to detect faint lights, and to prevent bias on the part of the observer, were given in detail. The zodiacal light may be divided into three portions—the *zodiacal cone;* the *zodiacal band;* and the *gegenschein.* This division is convenient in observation, saves confusion in description, and may be in part a natural one.

The zodiacal cone.—This, the zodiacal light proper, of most authors, is the well-known cone of light rising along the ecliptic, and best seen in the winter months in the West, immediately after the disappearance of twilight. The time of shortest twilight coincides with its greatest brilliancy. Several observations are given when the writer saw it cast a distinct *shadow* at that time. Its comparative brightness with the Via Lactea at different seasons were given, and its relation to the ecliptic discussed. It was stated that the cone in our latitude is not symmetrical; and that while its axis of greatest brightness lies exactly upon the ecliptic, its axis of symmetry is north of that line. An inner short cone of greater brightness was described. The warm color was shown to be due to atmospheric absorption. No pulsations were ever observed which could not be explained either by atmospheric changes or by changes in the eyesight of the observer. No periodic changes in the zodiacal light were observed; the same series of changes occurring each year with an equal amount of brilliancy. It was shown that while the zodiacal cone is frequently seen by moonlight, the moon appears to have no appreciable influence upon it. The account of the zodiacal cone closes with a description of its *spectrum*, which is always continuous and free from bright lines.

The zodiacal band.—This is an extremely faint zone of light, somewhat wider than the Via Lactea, which, like a strip of gauze, is stretched across the sky along the zodiac from horizon to horizon, and which can be seen at all times. It is a belt which forms a very faint prolongation of the zodiacal cone, and which, like it, is best seen when the ecliptic makes a large angle with the horizon. It is so faint that it can only be seen with difficulty. The best method of observing it is described. It is brightest along an inner line, and fades off more suddenly on its southern than on its nothern edge. It has a width of about 12°, and its central line is slightly north of the ecliptic. Observations prove the zodiacal band to be a constant and invariable phenomenon.

The gegenschein.—The gegenschein is a faint patch of light, some 7° in diameter, which nightly appears in that part of the zodiacal band, which is 180° from the sun. Night after night it shifts its place so as to keep opposite to the sun. It is decidedly brighter than the zodiacal band, and occasionally a central nucleus about 2° in diameter, of greater brightness, can be observed. While the brighter portion of the gegenschein is circular, its faint boundaries have sometimes the form of an oval, whose major axis is parallel to the ecliptic. A large number of maps of its position among the stars have been made, which show that while its central point is always 180° in longitude from the sun, it has a latitude of + 2°.

The moon zodiacal light.—An oblique cone of light in the proximity of the moon was described by Rev. G. Jones, but has not been detected by the writer. The light preceding moonrise rises at right angles to the horizon, and seems purely atmospheric. One observer has described comet-like tails on either side of the moon. The writer holds that such appearances are caused by diffraction through floating vapor, since they are never seen on clear nights.

The horizon light.—The phenomenon to which this name is applied, though having no connection with the zodiacal light, is so continually observed with the latter, and at certain seasons is so apt to be confounded with portions of it, that it is necessary to take it into account. The horizon light is a faint band of light with parallel sides, lying all around and parallel to the horizon, and separated from it by an interval of darkness. It is brightest, and terminates most abruptly on its lower edge. This sharp lower edge is 5° above the horizon, while the diffuse upper edge varies in altitude with the state of the atmosphere. The horizon light has a mean width of about 15°. It is purely atmospheric and appears to be caused by reflected starlight. It becomes very bright when the moon is above the horizon. Below the horizon light is a very dark space here called the *absorption band.* This quenches the light of the Via Lactea, the zodiacal cone, and all except the largest stars and planets, which last, while in it, are deeply colored. In the summer, when the ecliptic is low, the horizon light frequently blends with the zodiacal band.

THE ACTION OF SUNLIGHT ON GLASS.*

By Thomas Gaffield.

As great a variety of tints and colors appears after exposure to sunlight as is witnessed in the original specimens. A general classification of the changes of color produced by the sun in colorless glasses is as follows: 1. From white to yellowish. 2. From greenish to yellowish-green. 3. From brownish-yellow and greenish tints to purple. 4. From light-green or greenish-white to bluish. 5. From bluish and other tints to darker tints of the same colors. Every specimen of colorless glass exposed ten years shows some change of color or tint, except some white flint glass, such as is used for fine glassware and optical glass. The optical glasses with the exception of two specimens of crown, which became of a yellowish color, showed only a very slight change of tint, leading some to the opinion that oxide of lead, which enters largely into its composition, may act as a protecting shield against change by sunlight exposure. In experimenting for ten years with colored glasses of the main spectral colors (red, orange, yellow, &c.), no change was observed in any pot-metal specimens (colored throughout the body) save a slight darkening of the purple. A change to a purplish or yellowish color was observed in the colorless body of some of the flashed and stained specimens, when looking through the edges of these glasses, which are originally colored on the surface only. The sunlight coloration is not sufficient to be noticed in an observation through the surface of the glass. An experiment with pot-metals not of the primary colors, but of the intermediate ones which most nearly approach those which are produced in colorless glass by sunlight exposure, showed the following changes: First, from brownish tints to a flesh color; second, from flesh color to tints of violet or purple; third, from amber, olive and purple to darker tints of the same colors.

It is interesting to know that, so far as such colors in pot-metal were used in the old cathedral windows, the results of these experiments prove that they must have changed in color or tint, and that the glass which we see in these old churches to-day, and which has suffered sunlight exposure for centuries, must be of very different hue from that which it exhibited when it left the artist's studios or the glass factories of the mediæval ages. It is a curious fact, noticed by Pelouze and Percy, and confirmed by Mr. Gaffield's experiments, that, with some exceptions among the colored specimens, all of the glasses changed in tint or color by sunlight exposure can be restored to their original color by the heat of a glass-stainer's kiln, and can again be colored after a second exposure to sunlight; and that this coloration by sunlight and de-coloration by heat (of about the temperature of red heat) can be carried on indefinitely. Diffused light will also color glass, but only with a greatly diminished effect, proportioned to its comparison with the power of the direct rays of the sun.

ON A SOLUTION OF FERRIC GALLATE AND FERRIC OXALATE AS A REAGENT FOR THE QUANTITATIVE ANALYSIS OF AMMONIA.*

By Prof. N. B. Webster, of Norfolk, Va.

Preparation.—Ferric sulphate in solution is decomposed by gallic acid, and the resulting black ferric gallate is par-

* Read before the A. A. A. S., Boston.

tially decomposed by oxalic acid till the color is reduced to a bluish-black tinge.

Application.—A suitable quantity of the re-agent, prepared as above, is added to a solution of free ammonia or its carbonate, in the same way that Nessler's solution of mercuric per-iodide is used in Manklyn's well-known process.

Result.—The combination of the ammonia with part or all of the oxalic acid of the colorless ferric oxalate of the re-agent, and the blackening of the solution by the re-formation of ferric gallate.

Estimation of Ammonia.—By an imitation of a standard solution of ammonia with the re-agent, as in Wanklyn's mode of Nesslerizing. When the solution to be tested and the imitation solution correspond in color, it is inferred that they contain equal quantities of ammonia. In this process the standard ammonia test should be made from the *carbonate*, and its strength may be such that one litre shall contain one milligramme of ammonia, or one part in a million. Another and more direct way of estimating ammonia is by adding a standard test solution of oxalic acid to the blackened solution of the re-agent and liquid to be tested, till the original color is produced, and from the known quantity of oxalic acid used to calculate the quantity of ammonia in the resulting oxalate. Chemists will find this re-agent both convenient and sensitive.

THE UNITY OF NATURE.

By the Duke of Argyll.

In the preface to the first edition of the "Reign of Law," published in 1866, the following passage occurs:—"I had intended to conclude with a chapter on Law in Christian Theology. It was natural to reserve for that chapter all direct reference to some of the most fundamental facts of Human Nature. Yet, without such reference, the 'Reign of Law,' especially in the 'Realm of Mind,' cannot even be approached in some of its very highest and most important aspects. For the present, however, I have shrunk from entering upon questions so profound, and of such critical import, and so inseparably connected with religious controversy."

The great subject spoken of in this passage has ever since been present with me. Time, indeed, has only increased my sense of its importance. But the years have also added, perhaps in more than equal proportion, to my sense of its depth and of its difficulty. What has to be done, in the first place, is to establish some method of inquiry, and to find some secure avenue of approach. Before dealing with any part of the Theology which is peculiarly Christian, we must trace the connection between the Reign of Law and the ideas which are fundamental to all religions. It is to this preliminary work that the following chapters have been devoted. Modern Doubt has called in question not only the whole subject of inquiry, but the whole faculties by which it can be pursued. Until these have been tested and examined by some standard which is elementary and acknowledged, we cannot even begin the work.

It has appeared to me that not a few of the problems which lie deepest in that inquiry, and which perplex us most, are soluble in the light of the Unity of Nature. Or if these problems are not entirely soluble in this light, at least they are broken up by it, and are reduced to fewer and simpler elements. The following chapters are an attempt to follow this conception along a few of the innumerable paths which it opens up, and which radiate from it through all the phenomena of the Universe, as from an exhaustless centre of energy and of suggestion.

It is the great advantage of these paths that they are almost infinite in number and equally various in direction, To those who walk in them nothing can ever come amiss. Every subject of interest, every object of wonder, every thought of mystery, every obscure analogy, every strange intimation of likeness in the midst of difference—the whole external and the whole internal world—is the province and the property of him who seeks to see and to understand the Unity of Nature. It is a thought which may be pursued in every calling—in the busiest hours of an active life, and in the calmest moments of rest and of reflection. And if, in the wanderings of our own spirit and in the sins and sorrows of Human Life, there are terrible facts which resist all classification and all analysis, it will be a good result of our endeavors to comprehend the Unity of Nature, should it lead us better to see, and more definitely to understand, that which constitutes The Great Exception.

I commend these chapters to the consideration, and I submit them to the criticism, of those who care for such inquiries. Like the former Work, of which this is a sequel, some parts of it have appeared separately in another form. These have been reconsidered, and to some extent re-written; whilst a new meaning has been given to the reasoning they contain by the place assigned to them in a connected treatise.

The publication of it as a series of Articles, before its final appearance as a volume, will afford me, I hope, the advantage of hearing and of seeing what may be said and written of its errors or of its deficiencies. Perhaps, also, it may afford me an opportunity, before the whole of these Articles have appeared, of writing at least one more chapter on an important subject, for which leisure fails me now.

I.

GENERAL DEFINITIONS AND ILLUSTRATIONS OF THE UNITY OF NATURE—WHAT IT IS, AND WHAT IT IS NOT.

The system of Nature in which we live impresses itself on the mind as one system. It is under this impression that we speak of it as the Universe. It was under the same impression, but with a conception specially vivid of its order and its beauty, that the Greeks called it the Kosmos. By such words as these, we mean that Nature is one whole—a whole of which all the parts are inseparably united—joined together by the most curious and intimate relations, which it is the highest work of observation to trace, and of reason to understand.

I do not suppose that there is any need of proving this—of proving, I mean, that this is the general impression which Nature makes upon us. It may be well, however, to trace this impression to its source—to see how far it is founded on definite facts, and how far it is strengthened by such new discoveries as science has lately added to the knowledge of mankind.

One thing is certain: that whatever science may have done, or may be doing, to confirm man's idea of the unity of Nature, science, in the modern acceptation of the term, did not give rise to it. The idea had arisen long before science in this sense was born. That is to say, the idea existed before the acquisition of physical knowledge had been raised to the dignity of a pursuit, and before the method and the results of that pursuit had been reduced to system. Theology, no doubt, had more to do with it. The idea of the unity of Nature must be at least as old as the idea of one God; and even those who believe in the derivation of Man from the savage and the brute, cannot tell us how soon the Manotheistic doctrine arose. The Jewish literature and traditions, which are at least among the oldest in the world, exhibit this doctrine of the purest form, and represent it as the doctrine of primeval times. The earliest indications of religious thought among the Aryan races point in the same direction. The records of that mysterious civilization which had been established on the Nile at a date long anterior to the call of Abraham, are more and more clearly yielding results in harmony with the tradition of the Jews. The Polytheism of Egypt is being traced and tracked through the ready paths which led to the fashioning of many Gods out of the attributes of One.[1] Probably those who do not accept this conclusion as historically proved may hold rather that the idea of the unity of Nature preceded the idea of the unity of God, and that Monotheism is but the form in which that earlier idea became embodied. It matters not, so far as my present purpose is concerned, which of these two has been the real order of events. If the law prevailing in the infancy of our race has been at all like the law prevailing in the infancy of the individual, then Man's first beliefs were derived from authority, and not from either reasoning or observation. I do not myself believe that in the morning of the world The-

[1] Renouf, "Hibbert Lectures," 1879. p. 89.